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Engineering countermeasures to reducing unintentional yellow-light running owing to dilemma zone

Xiaoyi Lin[a] , Lin Cheng[a]

[a] Department of transportation, Southeast University, Nanjing, *210096,* China

Abstract

Yellow-light running problem has been recognized as a significant safety problem in China as well as throughout the world .Unintentional yellow-light running can be caused by dilemma zones. By analyzing the drivers behaviours in the dilemma zone, the factors affecting unintentional yellow-light running and engineering countermeasures are put forward, including adjusting speeds approaching the intersection, adaptive signalizing and advance warning signs. In sight of the research, some engineering countermeasures can be used for reducing the phenomenon of yellow-light running.

Keywords: yellow-light running; engineering countermeasure; traffic safety; dilemma zone

1. Introduction

Yellow-light running has become the major cause of traffic accidents caused in the crossing. Yellow light running is an act of traffic violation, which should be punished according to the law. In 2013 Chinese Ministry of Public Security issue policy emphasizes that yellow-light running will be punished. The behaviour of yellow-light running has been widely discussion and attention. Yellow light is a remainder of the driver that signal is about to transform. Drivers when approaching an intersection have the choice either to decelerate to stop or to continue to proceed at the onset of yellow signal. The vehicles which have crossed the stop line at the onset of yellow signal can continue to proceed. If the vehicles that have not crossed the stop line at the onset of yellow signal, it will belong to yellow-light running when choosing to continue. When the signal turns green to yellow, the vehicle approaching the intersection may not safely come to a stop before the stop line which may lead to yellow-light running. If the driver decelerates to stop, it will have rear-end collision. The reason that vehicles run yellow lights are varied, there are no specific categories of drivers who run yellow lights, but studies have shown a yellow light violation can be either deliberate or unintentional. The deliberate yellow-light running is frequently due to driving behaviours such as drivers taking yellow lights as green lights and trying to beat the signal. While unintentional yellow-light running is often due to dilemma zone caused by inappropriate signal timing or poor circumstances. This type of yellow light violation cannot be decreased by law enforcement. So some engineering

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enforcement countermeasures should be done to decrease unintentional yellow-light running (Chiu and Herman, 1996; Qiao and Dong, 2009).

2. The Notion of Dilemma Zone

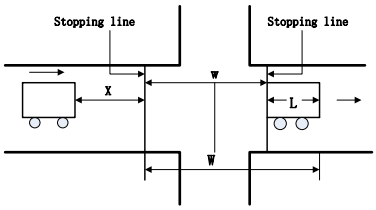

Fig.1. The diagram of intersection

Dilemma zone has been defined to be the situation where drives can neither cross the stop line before the onset of red if they stay within speed limit nor can stop the vehicle by applying a comfortable deceleration. Unintentional yellow-light running is one of the forms of dilemma zones. In order not to beat the yellow light, drivers when approaching an intersection have to choose to stop before the stop line at the onset of yellow light (Papaioannou, 2007; Sharma et al., 2010). A minimum safe stopping distance is necessary to secure a safe stop. The safe stopping distance is depended on their initial approaching speed v_0, the drivers' perception/reaction time t_0, the vehicles' performance in decelerating a. The safe stopping distance of those vehicles should be longer than x as equation (1) shown. $x \geq v_0 t + v_0^2 / 2a$. If $x_0 < x$, some driver will be in the dilemma zone. Drivers in the dilemma zone appear to have the highest risk of being in a collision. If they make a urgent deceleration to stop, they may be involved in a rear-end collision if a driver behind him has not decelerated to stop.

However according to the data experiment from DCCI, it displayed the brake situations where vehicles at different distance found yellow light was lit up with the speed between 20 kilometers per hour and 80 kilometers per hour. The data showed if vehicles are 5 meters away from the stop line at the onset of yellow light, all the vehicles will have yellow-light running inevitably whether the speed is 20 kilometers per hour or 80 kilometers per hour. The results are shown in figure 2.

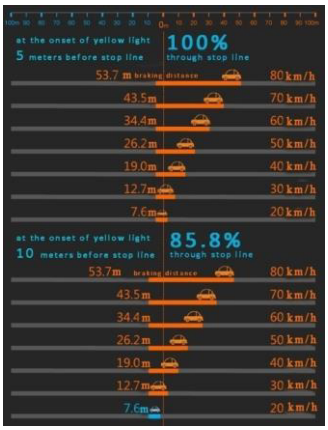

Fig.2.Brake situation experiment from DCCI

3. Engineering Countermeasures to Reduction Yellow-Light Running

From the data shown above, we can see yellow-light running need to be paid attention, which is associated with dilemma zones. Dilemma zone is related to the speed approaching the intersection, the driver' perception /reaction time and the vehicles' decelerating performance. Though yellow-light running has not been seriously punished, it relates to the safety at the intersection. So the engineering countermeasures must be done according to the above areas.

3.1. Reduction yellow-light running by adaptive signaling

One potential countermeasure to reduce yellow-light running is to reduce the likelihood that a vehicle will be in a dilemma zone at the onset of yellow light. This can be accomplished by placing vehicle detectors before the dilemma zone. Assume that a series of detectors are placed on the roadway upstream of an intersection in such a way that can simultaneously record the position and speed of all vehicles on the roadway. With the information provided by these detectors, it is possible to predict whether these vehicles will be caught in dilemma zones. We can keep extending or cutting back the green interval until no vehicle falls in a dilemma zone by adaptive signaling, and thus reduce the number of vehicles in a dilemma zone to zero. However, this may increase the delay time for the cross traffic and reduce the overall speed of the traffic. Therefore, an upper bound for the green interval extension or cutback should be set. In order to maintain the orderly rhythm in the coordination of a series of traffic signals, one may want to maintain the overall length of the signal cycle, which is often computed using some optimization program (McCoy and Pesti, 2003; Pant and Cheng, 2001). The process is shown in Figure 3.

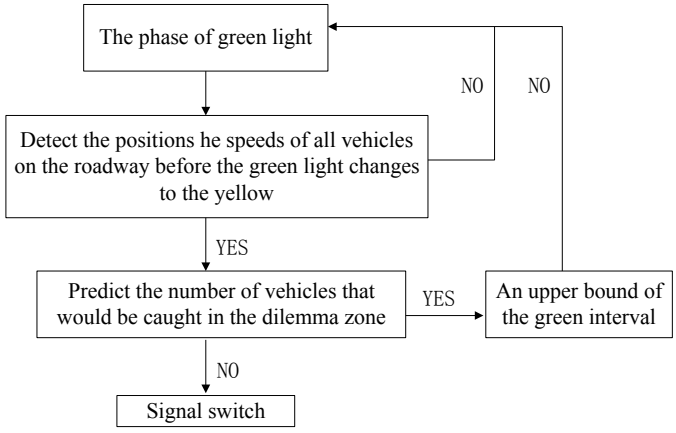

Fig.3. The program of adaptive signaling

Loop detector can be used as advance detection. When the detectors do not detect the vehicle on the major road, the right of way may shift to the minor road. These help to increase the protection of dilemma zone and decrease the phenomenon of yellow-light running.

3.2. Adjust speed approaching the intersection

Consider discrete feature (different velocity and acceleration), drivers' judgment and instable action as different individuals, the phenomenon of yellow-light running that caused by dilemma zones cannot eliminated theoretically. Mistaken judgment and action may lead to some traffic accident at the intersection. Some range marks or deceleration zones can be set close to the intersection, which can remind drivers of appropriate deceleration within 30 meters away from the intersection. In order not to be rear-end collision, driver can continue to move on when they are within 5 meters away from the intersection at the onset of yellow light. Other vehicles should decelerate to stop.

3.3. Reduction yellow-light running by adaptive signaling

There are many passive signs just like many other traffic signs and these indicate the presence of an intersection ahead and alert the drivers. The signs are shown in figure (a). In order to reduce the phenomenon of yellow-light running, advance warning for the end of the green phase is needed. We can advise relevant departments that the green light can be shined 8 seconds before yellow light lit up by the data analysis from DCCI when there is no adaptive signals. This kind of signs have flashers which start flashing a few seconds before the onset of the yellow interval and continue to flash until the end of the red interval. The most common sign is "Prepare to Stop When Flashing" sign (Li et al., 2009). The signs are shown in figure 4.Acknowledgements

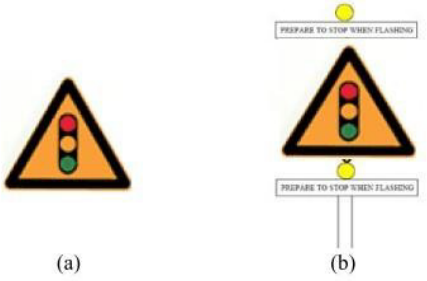

Fig.4 Advance warning signs

4. Conclusion

Dilemma zone is the area near an intersection where drivers going the legal speed limit can neither stop nor clear the intersection successfully. The phenomenon of yellow-light running is related to dilemma zones. It is highest priority to reduce yellow-light running by engineering countermeasures. Engineering protections with adjusting the speed approaching an intersection, adaptive signaling and advance warning signs prevents drivers from being caught in dangerous situations, and reduces the number of unintentional yellow running violation and the traffic.

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